CONSERVATION AGRONOMY TECHNICAL NOTES

U. S. DEPARTMENT OF AGRICULTURE — NEW MEXICO — SOIL CONSERVATION SERVICE

NOTE NO. 24

January 19, 1973

RE: PLANT FOOD ELEMENTS - PHOSPHORUS

The attached Technical Note on Phosphorus is the second of a planned series to provide information on plant food elements which are most likely to be deficient in our soils.

If additional copies of this Technical Note are needed for individual references and use in field work, request them from the Plant Science Section.

Attachment

AO
WRTSC, Portland - 2
Adjoining States - 1

11-64 4-L-19461

PHOSPHORUS - ABUNDANT or SCARCE?

It is not possible for either plant or animal life to exist without phosphorus and unfortunately the soil is the chief source of this plant food element. A lack of phosphorus not only retards plant growth but also lowers the tone and vigor of both plants and animal. Animals must get their phosphorus indirectly by utilizing plants for food, while the plants themselves must secure their phosphorus directly from the soil.

The plow layer of soil on an acre of ordinary loam soil weighs about 2,000,000 pounds. Soils in the United States in general contain less than 0.1 per cent of total phosphorus, all of which is not available. In a large portion of the United States, where cultivation has taken place for many years, the phosphorus content may have been depleted to the point where it is less than one-half of this amount. This means that in many parts of our country our soils have only about 1,000 pounds of phosphorus per acre in the plow layer. On the average, the phosphorus content of our surface soils is only about one-half that of nitrogen and one-twentieth that of potassium.

Unsatisfactory plant growth is more often due to a shortage of phosphorus than of any other plant food element. Phosphorus is intimately associated with all life processes and is a vital part of every living cell. Without phosphorus life would not be possible.

We are fortunate in this country in having almost one-third of the total known world supply of phosphorus in the form of rock phosphate deposits. Most of our rock phosphate supply is in Florida, Tennessee and the Rocky Mountain states. Some have estimated we have enough phosphates to last us for more than 2,000 years from our presently known deposits. Seeds of plants are relatively high in phosphorus. The bones of animals consist chiefly of calcium phosphate. Milk is also rich in phosphorus. Since grain and livestock are raised and sold these enterprises gradually deplete soil phosphorus unless it is replaced from time to time.

AVAILABILITY of SOIL PHOSPHORUS

Availability is a term used to indicate the quantity of phosphorus in phosphate rock or in commercial phosphate materials which is in a condition where it can be used by growing plants. Tests for this determination are based on a combination of solubility in water and neutral ammonium citrate solution.

Phosphorus in phosphate rock has a very low degree of availability to plants. Often less than half of one per cent is available to plants in any one growing season. To offset this, phosphate rock

is treated with sulfuric, phosphoric or nitric acids to break the apatite structure and to form available phosphorus. However, the soluble phosphorus formed by these treatments is very reactive with the soil and its availability to growing plants diminishes at a rapid rate. This tieing up of soluble phosphorus process is called fixation.

1. In acid soils fixation is caused mostly by combination with iron and aluminum.

2. In neutral or alkaline soils the soluble fertilizer phosphorus will combine with calcium and become less available to plants. However, calcium phosphates are not nearly as difficult for plants to use as are some aluminum and iron phosphates.

3. Fixation can be lessened by minimizing the area of contact between the fertilizer and the soil. Granules such as in pelleted form of fertilizers, present much less surface for contact per unit of phosphorus than do equal amounts of pulverized fertilizer.

4. Banding of phosphorus fertilizer materials also reduces contact and delays fixation.

5. Fertilizing at higher rates also results in less fixation problems since more of the soluble iron, aluminum or calcium in the soil is tied up by the phosphorus and less remains to fix the additional applied phosphorus.

6. Due to fixation, it is not uncommon for only 5-10 per cent of added phosphorus fertilizer to be taken up by the crop to which applied in any one given year. Under favorable conditions somewhat larger percentages are recovered.

7. There is a carry-over of phosphorus from fertilizer phosphorus for several years after its application. The length of time and effectiveness of this residual value will be greater on neutral and calcareous soils than on acid soild because of extreme fixation with iron and aluminum in the acid soils.

8. On acid soils the period of recovery of phosphorus fertilizers can usually be extended by liming.

SOME FUNCTIONS OF PHOSPHORUS

1. It is an active ingredient of protoplasm and is therefore essential to all plant growth.

2. Stimulates early root formation and growth.

3. Is responsible for giving plants a rapid and vigorous start.

4. It hastens maturity.

5. It increases the ratio of grain to straw as well as increasing total yield.

6. Stimulates blooming and aids in seed formation and production.

7. Helps cause winter hardiness in fall-seeded grains and hay crops.

8. Helps improve the palatibility of plants and stimulates the formation of fats and convertible starches.

9. Since it stimulates rapid cell development in the plant, phosphorus naturally increases the resistance to disease.

10. It contributes favorably to the general hardiness of the plant.

An excess of phosphorus does not cause the harmful effects of excess nitrogen and has an important balancing effect upon the plant.

SOME SYMPTOMS OF A PHOSPHORUS-STARVED PLANT

1. Purplish color of leaves, stems and branches. The tips of older leaves will often be dead.

2. Slow growth and slow maturity.

3. A small slender stalk in corn.

4. A lack of stooling in small grains.

5. Lack of, or poor, fruit and seed development.

6. Low yields of grain, fruit and seed.

7. Small growth, especially root development.

SOME PRINCIPAL SOURCES AND AVERAGE COMPOSITION OF PHOSPHORUS FERTILIZER MATERIALS

Phosphate Materials	Chemical Formula	Total Nitrogen N%	Available Phosphoric Acid P_2O_5%	Water Soluble Potash K_2O%	Combined Calcium Ca%	Combined Sulfur S%	Equivalent Acidity or Basicity in Lbs. of Calcium Carbonate Acid	Base
(Mono) Ammonium Phosphate	$NH_4H_2PO_4$	11	48	—	1.4	2.6	58	—
Ammonium Phosphate Sulfate	$NH_4H_2PO_4 \cdot (NH_4)_2SO_4$	13	39	—	—	7.0	69	—
Ammonium Phosphate Sulfate	40% $NH_4H_2PO_4$ 60% $(NH_4)_2SO_4$	16	20	—	0.6	15.4	88	—
Ammonium Phosphate Nitrate	$NH_4H_2PO_4 \cdot NH_4NO_3$	24	20	—	—	—	60	—
Ammonium Phosphate Nitrate	$NH_4H_2PO_4 \cdot NH_4NO_3$	27	14	—	—	—	60	—
Diammonium Phosphate	$(NH_4)_2HPO_4$	21	53	—	—	—	75	—
Ammoniated Single Superphosphate	Complex Ammonia Compounds	3-4	16-18	—	15.0	12.0	4-7	—
Ammoniated Triple Superphosphate	Complex Ammonia Compounds	4-6	42-45	—	12.9	1.0	11-14	—
Nitric Phosphates	Complex Compounds	14-20	14-20	—	8.0-10.0	0-4.0	15-29	—
Superphosphate (Single)	50% $CaSO_4$ 30% $CaH_4(PO_4)_2$	—	18-20	—	18.0-21.0	12.0	—	—
Superphosphate (Double or Triple)	$CaH_4(PO_4)_2$	—	42-46	—	12.0-14.0	1.0	—	—
Liquid Phosphoric Acid	H_3PO_4	—	52-54	—	—	—	110	—

HOW TO FIGURE FERTILIZER EQUIVALENTS - PHOSPHORUS CONVERSIONS BASED ON CONTAINED PHOSPHORUS

Phosphoric Acid (P_2O_5) in pounds X 0.4364	= Phosphorus in pounds
Phosphorus (P) in pounds X 2.2914	= Phosphoric Acid (P_2O_5) in pounds
Phosphorus (P) in pounds X 3.0662	= Phosphate (PO_4) in pounds
Phosphate (PO_4) in pounds X 0.3261	= Phosphorus (P) in pounds
Phosphorus Pentoxide (P_2O_5) in pounds X 1.3381	= Phosphate (PO_4) in pounds
Phosphate (PO_4) in pounds X 0.7473	= Phosphorus Pentoxide (P_2O_5) in pounds
Mono Ammonium Phosphate ($NH_4H_2PO_4$) in pounds X 0.6170	= Phosphorus Pentoxide (P_2O_5) in pounds
Phosphorus Pentoxide (P_2O_5) in pounds X 1.6207	= Mono Ammonium Phosphate ($NH_4H_2PO_4$) in pounds
Diammonium Phosphate $(NH_4)_2HPO_4$ in pounds X 0.5374	= Phosphorus Pentoxide (P_2O_5) in pounds
Phosphorus Pentoxide (P_2O_5) in pounds X 1.8607	= Diammonium Phosphate $(NH_4)_2HPO_4$ in pounds
Dibasic Calcium Phosphate ($CaHPO_4 \cdot 2H_2O$) in pounds X 0.2329	= Calcium (Ca) in pounds
Calcium (Ca) in pounds X 4.2938	= Dibasic Calcium Phosphate ($CaHPO_4 \cdot 2H_2O$) in pounds
Free Lime (CaO) in pounds X 1.8437	= Tricalcium Phosphate $Ca_3(PO_4)_2$ in pounds
Tricalcium Phosphate-$Ca_3(PO_4)_2$ in pounds X 0.5424	= Free Lime (CaO) in pounds

RELATIVE PHOSPHORUS REQUIREMENTS FOR SOME NEW MEXICO CROPS AND PLANTS

Very High Requirements	High Requirements	Medium Requirements	Low Requirements
Beets, early	Alfalfa	Beans, Lima or String	Apples
Beets, late	Asparagus	Beans, dry field	Bent Grass
Cabbage, early	Barley	Bluegrass, Kentucky	Blackberries
Cauliflower, early	Beets, Sugar	Bromegrass	Blueberries
Celery, early	Bermuda Grass	Carrots, late	Cherries
Lettuce, Head	Broccoli	Clover, Alsike	Deciduous Plants
Lettuce, Leaf	Brussels Sprouts,	Clover, Ladino	Deciduous Trees
Potatoes, early	Cabbage, late	Clover, white	Evergreen Plants
Potatoes, late	Carrots, early	Corn, field, grain	Evergreen Shrubs
Radishes	Cauliflower, late	Corn, sweet, late	Evergreen Trees
Spinach	Celery, late	Cotton	Millet
	Clover, Red	Desicuous Shrubs	Peaches
	Corn, silage	Fescue Grass, tall	Pears
	Corn, sweet, early	Flowers, Perennials and Bulbs	Putting Greens
	Cucumbers	Grapes	Raspberries
	Egg Plant	Grass, Sudan	Rye
	Flowers, Annual	Lawns, Parks and Fairways	Rye Grass
	Muskmelons	Oats	Timothy
	Onions	Orchard Grass	
	Peas, early	Parsnips	
	Rhubarb	Peanuts	
	Sorghum, silage	Peas, field	
	Squash, early	Playing Fields	
	Tomatoes, early	Potatoes, sweet	
	Tomatoes, late	Pumpkins	
	Turnips	Sorghum Grain	
	Wheat	Soy Beans	
		Squash, late	
		Strawberries	
		Vetch, hairy	
		Watermelons	

REFERENCES

"Our Land and Its Care" - National Plant Foods Institute - Third Edition, Second Printing - 1956

"Phosphorus in Soils" - Plant Food Review Final Issue #1, 1969

"Western Fertilizer Handbook" - by the Soil Improvement Committee of the California Fertilizer Association - Fourth Edition, Second Printing - 1968

"La Motte Soil Handbook" - Research Department, La Motte Chemical Products Co. - reprinted March, 1971